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SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT WE, Hidehiko Kira, a citizen of Japan residing at c/o FUJITSU LIMITED, 1015, Kamikodanaka, Nakahara-ku, Kawasaki-shi, Kanagawa, 211 Japan, Masanao Fujii, a citizen of Japan residing at c/o FUJITSU LIMITED, 1015, Kamikodanaka, Nakahara-ku, Kawasaki-shi, Kanagawa, 211 Japan and Naoki Ishikawa, a citizen of Japan residing at c/o FUJITSU LIMITED, 1015, Kamikodanaka, Nakahara-ku, Kawasaki-shi, Kanagawa, 211 Japan have invented certain new and useful improvements in

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METHOD AND SYSTEM FOR FABRICATING A SEMICONDUCTOR DEVICE

of which the following is a specification : -



TITLE OF THE INVENTION

METHOD AND SYSTEM FOR FABRICATING A
SEMICONDUCTOR DEVICE

5 BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a method and a system for fabricating a semiconductor device, and more particularly, to a method and a system
10 for fabricating a semiconductor device, in which a flip-chip connection is performed.

Recently, according to a progress of a high-density integration of the semiconductor device, the flip-chip connection with bumps is frequently used to
15 perform a high-density mounting of a semiconductor chip and to shorten a length of routing lines for requirement of a fast operation. Further, such a semiconductor device has to be fabricated with a low cost. To meet the above requirements, it is necessary
20 to achieve a considerably precise alignment in the mounting of the semiconductor chip with the low cost.

2. Description of the Prior Art

FIGS. 1A to 1E show illustrations for explaining fabrication procedures of a conventional
25 flip-chip-type semiconductor device. In FIG. 1A, a given number of stud-bumps 14 (bonding balls only) are formed on aluminum pads of a semiconductor chip 11 by using a wire 13 (made of, for example, aluminum, copper, gold, etc.) with a wire-bonding technology.

30 In heights of the stud-bumps 14, there is generally a dispersion of about 20 μm . Therefore, in FIG. 1B, to make the heights of the stud-bumps 14 uniform, the stud-bumps 14 of the semiconductor chip 11 are pressed against a flat glass plate 15 for leveling.

35 In FIG. 1C, in advance, a conductive adhesive 16 is skidded on a flat glass plate 15a (may be the flat glass plate in FIG. 5B), and a portion 16a of the

1 conductive adhesive 16 on the flat glass plate 15a is
adhered to an end of each stud-bump 14 by pressing the
stud-bumps 14 against a surface of the conductive
adhesive 16 for a given period.

5 In FIG. 1D, based on a number of the stud-
bumps 14 on the semiconductor chip 11, a thermosetting
insulating adhesive 18 is applied on a substrate 17, in
which mounting pads 17a are formed, for reinforcement
by a screen-printing method. And the semiconductor
10 chip 11 which is absorbed by a bonding head (not shown)
is moved over the substrate 17.

In FIG. 1E, the stud-bumps 14 on the semiconductor chip
11 are aligned to the mounting pads 17a on the
substrate 17. And subsequently, these components are
15 pressed and heated by the bonding head. In this way,
the flip-chip connection and the mounting process of
the semiconductor chip 11 to the substrate 17 are
simultaneously performed.

 In this case, the bonding head is equipped
20 with a heat source, and the insulating adhesive 18 is
thermoset by the heat source to reinforce the flip-chip
connection.

 As a method of heating, another method is
known in Japanese Laid-Open Patent Application No.5-
25 67648, wherein the alignment, the heating, and the
pressing are simultaneously performed by nozzles
arranged around the bonding head to jet hot winds.

 Further, another heating method is known in
Japanese Laid-Open Patent Application No. 3-184352. In
30 this method, not shown in a drawing here, the bumps of
the semiconductor chip are aligned and mounted by only
the heating over the mounting pads of the substrate 17.
After that, the thermosetting insulating adhesive is
applied and infiltrated into the mounting pads and the
35 bumps. Then the insulating adhesive is thermoset by
heating it in a heating block or thermostat.

 In FIG. 1E, the mounting pads 17a and the

1 stud-bumps 14 are not only aligned and pressed, but are
also heated to thermoset the insulating adhesive 18.
However, a fabrication apparatus for performing such
processes must have a considerably precise alignment
5 mechanism and a heating mechanism. A cost of such a
fabrication apparatus is high. Therefore, by spending
time for thermosetting the insulating adhesive 18 with
the high-cost fabrication apparatus, there is thus a
problem that a mounting cost of the semiconductor chip
10 is increased.

On the other hand, in the Japanese Laid-Open
Patent Application No.3-184352, first the semiconductor
chip is mounted by pressing only, and next it is
heated. However, a difference (about 4 times) in
15 thermal expansion between the semiconductor chip and
the substrate makes the flip-chip connection imperfect.

SUMMARY OF THE INVENTION

It is an object of this invention to provide
20 a method and a system for fabricating a semiconductor
device, in which a fabrication apparatus cost and a
fabrication cost may be reduced, and a perfect flip-
chip connection may be performed, in which the
disadvantages described above are eliminated.

25 The object described above is achieved by a
fabrication method of a semiconductor device comprising
the steps of: (a) forming a given number of projection
electrodes on each of a given number of semiconductor
chips, and applying a thermosetting insulating adhesive
30 to areas of mounting parts where the semiconductor
chips are to be mounted on a substrate; (b) heating the
thermosetting insulating adhesive on the substrate with
a half-thermoset temperature; (c) aligning the
semiconductor chips to the mounting parts of the
35 substrate and performing a first fixing of the
semiconductor chips with a first pressure; and (d)
heating the substrate, on which the semiconductor chip

1 is fixed, with a thermosetting temperature of the
thermosetting insulating adhesive, and performing a
second fixing of the semiconductor chips with a second
pressure.

5 The object described above is also achieved
by the fabrication method of the semiconductor device
described above, wherein the first pressure is lower
than the second pressure.

The object described above is further
10 achieved by the fabrication method of the semiconductor
device described above, wherein the second fixing is
simultaneously performed for each of semiconductor
chips with the second pressure.

In addition, the object described above is
15 achieved by the fabrication method of the semiconductor
device described above, wherein the given number of the
projection electrodes are formed as studs by wire
bonding, the studs being leveled.

The object described above is further
20 achieved by the fabrication method of the semiconductor
device described above, wherein the step (a) further
comprises the step (a-1) of forming a conductive
adhesive on the projection electrodes.

The object described above is also achieved
25 by the fabrication method of the semiconductor device
described above, wherein in the step (a-1), the
conductive adhesive on the projection electrodes is
formed by a conductive adhesive, which has been skidded
on a plate, being transcribed onto the projection
30 electrodes.

The object described above is also achieved
by a fabrication system of a semiconductor device
comprising: a chip loading device forming a given
number of projection electrodes on each of a given
35 number of semiconductor chips; a substrate loading
device loading a substrate having mounting parts on
which the semiconductor chips are to be mounted; an

1 adhesive-application device applying a thermosetting
insulating adhesive to areas of the mounting parts of
the substrate; an alignment-and-pressing device heating
the thermosetting insulating adhesive on the substrate
5 with a half-thermosetting temperature, aligning the
semiconductor chips to the mounting parts of the
substrate, and performing a first fixing of the
semiconductor chips with a first pressure; and a
pressing-and-heating device heating the substrate, on
10 which the semiconductor chips are fixed, with a
thermosetting temperature of the thermosetting
insulating adhesive, and performing a second fixing of
the semiconductor chips with a second pressure.

According to the fabrication method of the
15 semiconductor chip, first the semiconductor chip, on
which the projection electrodes are formed, is aligned
to the substrate, and is fixed in the first fixing by
the pressing only. After that, the pressing and
heating for thermosetting the insulating adhesive are
20 performed. In such way, the first fixing is performed
in a different process from the pressing and heating.

In such a process, a less expensive apparatus
may be individually applied for an alignment mechanism
and a heating mechanism, so that a cost of fabrication
25 apparatus may be reduced. And since at the final
pressing and heating, the alignment is already
finished, several processes, such as pressing, heating,
and aligning, may be performed by a single process.
Thus, throughput is improved, and, as a result, a
30 fabrication cost may be also reduced.

And according to the fabrication method of
the semiconductor chip, the first pressure is lower
than the second pressure. Therefore, when the
semiconductor chip with the projection electrodes is
35 fixed in the ^{second} first fixing with the ^{second} first pressure, a
~~dispersion of a degree of collapse of the projection~~
electrodes may be ^{deformed uniformly} absorbed.

1 Further according to the fabrication method
of the semiconductor chip, the second fixing of the
semiconductor chips is performed for each semiconductor
chip with the second pressure. Therefore, multi-heads
5 for pressing and heating become available, which leads
to an improved mounting operation.

Other objects and further features of the
present invention will be apparent from the following
detailed description when read in conjunction with the
10 accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A to 1E show illustrations for
explaining fabrication procedures of a conventional
15 flip-chip-type semiconductor device;

FIG. 2 shows an overall block diagram of a
fabrication system for realizing a fabrication method
according to the present invention;

FIG. 3 shows a flowchart explaining
20 fabrication procedures of a semiconductor device
according to the present invention;

FIGS. 4A to 4F show illustrations for
explaining the fabrication procedures of the
semiconductor device according to the present
25 invention; and

FIG. 5 shows an overall illustration of the
semiconductor device as a multi-chip module fabricated
according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First, a description will be given of first
embodiment of a fabrication method of a semiconductor
device according to the present invention, by referring
to FIG. 2. FIG. 2 shows an overall block diagram of a
35 fabrication system 21 for realizing the fabrication
method according to the present invention.

In the fabrication system shown in FIG. 2, a

1 chip loader 22 supplies a semiconductor chip on which a
given number of electrode pads (e.g. aluminum pads) are
formed, and a bonder 23 forms stud-bumps as projection
electrodes on the semiconductor chip by means of a
5 wire-bonding technology.

A transcribing device 24 transcribes a
conductive adhesive on a surface of the stud-bumps. A
cure/alignment-and-pressing device 25 heats a substrate
with an adhesive-half-thermosetting temperature, and
10 aligns the semiconductor chip, on which stud-bumps are
formed, to the substrate by a stepper to perform a
first fixing with a first pressure.

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A substrate loader 26 supplies the substrate
on which mounting pads as a mounting part are formed
15 based ^{on} ~~of~~ a number of the stud-bumps of each
semiconductor chip. An adhesive-application device 27
applies, to the supplied substrate, a constant amount
of a thermosetting insulating adhesive on areas of the
mounting pads which correspond to each semiconductor
20 chip, by using a dispenser, and then supplies the
substrate to the cure/alignment-and-pressing device 25.

A pressing-and-heating device 28 presses the
semiconductor chip fixed on the substrate with a second
pressure, and heats it with a temperature by which the
25 insulating adhesive is thermoset to perform a second
fixing. An unloader 29 issues the substrate on which
the semiconductor chip is mounted.

FIG. 3 shows a flowchart explaining
fabrication procedures of the semiconductor device
30 according to the present invention, and FIGS. 4A to 4F
show illustrations for explaining the fabrication
procedures of the semiconductor device according to the
present invention. First, a semiconductor chip 31 is
moved from the chip loader 22 to the bonder 23, stud-
35 bumps 34 are generated from a wire 33 (for example an
aluminum wire, and for electrode pads made of copper or
gold, a copper wire or a gold wire) by a capillary 32,

1 and subsequently, by means of a wire-bonding
technology, the stud-bumps 34 are formed on electrode
pads (not shown) which are formed on the semiconductor
chip 31 (a step S1 in FIG. 3, FIG. 4A).

5 In these stud-bumps 34 on the semiconductor
chip 31, there is a dispersion of height of about 20
 μm . Therefore, to make their height uniform, the stud-
bumps 34 are pressed to a flat glass plate 35 for
leveling (a step S2 in FIG. 3, FIG. 4B). Then, the
10 semiconductor chip 31 is moved to the transcribing
device 24.

In the transcribing device 24, in advance, a
conductive adhesive 36 is skidded thinly on a flat
glass plate 35a. A conductive adhesive 36a is
15 transcribed on surfaces of the stud-bumps 34 by
pressing the stud-bumps 34 to the conductive adhesive
36 with heating (a step S3 in FIG. 3, FIG. 4C). The
skidding of the conductive adhesive 36 on the flat
glass plate 35a is performed by pushing out the
20 conductive adhesive 36 onto the flat glass plate 35
with a rubber contacted with the conductive adhesive 36
using a skidder.

On the other hand, in the substrate loader
26, mounting pads 37a are formed on a substrate 37
25 based on a number of the stud-bumps of the
semiconductor chip 31, and this substrate 37 with the
mounting pads 37a is supplied to the adhesive-
application device 27. In this device 27, a
thermosetting insulating adhesive 38 is applied in each
30 area of the mounting pads 37a corresponding to each
semiconductor chip 31 (a step S4 in FIG. 3). And
subsequently, the substrate 37 is moved over a heat
plate of the cure/alignment-and-pressing device 25
(FIG. 4D).

35 This substrate 37 is precured at a
temperature by which the insulating adhesive 38 is
half-thermoset on the substrate 37, by the heat plate

1 39 (a step S5 in FIG. 3). At a later step, when the
substrate 37 on which the semiconductor chip 31 is
mounted is moved to the pressing-and-heating device 28,
a positioning gap may happen due to a moving shock.
5 For preventing an occurrence of such a positioning gap,
this precuring process is implemented to obtain strong
adhesion with the semiconductor chip 31 by half-
thermosetting the insulating adhesive 38 (~~reducing a~~
~~degree of viscosity and thixotropy~~). ^{a.}

10 Then, in the device 25, the semiconductor
chip 31 is absorbed by a bonding head 40, and each
stud-bump 34 is aligned over a respective mounting pad
37a of the substrate 37. At the same time, the bonding
head 40 with the semiconductor chip 31 is pressed
15 against the mounting pads 37a with the first pressure
to perform a tentative fixing (a step S6 in FIG. 3,
FIG. 4E). Then, the insulating adhesive 38 on the
substrate 37 is cured by the heat plate 39.

The substrate 37, onto which all of the
20 semiconductor chip 31 is tentatively fixed, is moved to
the pressing-and-heating device 28 by a transiting
rail, etc., to dispose it on an adhesive-hardening
stage 41 (a step S7 in FIG. 3). A heater block 42,
which is able to move freely in a vertical direction,
25 is positioned over the adhesive-hardening stage 41.
And the heater block 42 is equipped with a given number
of pressing-and-heating heads 42a, the given number
corresponding to a number of semiconductor chips 31 or
a given number of semiconductor-chip groups. Each of
30 the pressing-and-heating heads 42a has a function which
can keep the heads 42a at the same vertical height.

By heating the heater block 42, heat of a
temperature which the insulating adhesive 38 is
thermoset is transmitted to the pressing-and-heating
35 heads 42a. When the heater block 42 is moved downward,
the pressing-and-heating heads 42 are pressed against
each semiconductor chip 31 with the second pressure,

1 and simultaneously thermoset the insulating adhesive 38
to perform the second fixing (a step S8 in FIG. 3, FIG.
4F).

5 In this case, the second pressure is set
larger than the first pressure. This method may absorb
a dispersion of a degree of collapse of the bumps 34,
and a dispersion of a thickness of the mounting pads
37a of the substrate 37, which occur when the substrate
37 is pressed. This method may also absorb a
10 difference of thermal expansion between the substrate
37 and the semiconductor chip 31 during heating. These
procedures achieve an⁹ significantly improved flip-chip
connection.

FIG. 5 shows an overall illustration of the
15 semiconductor device as a multi-chip module fabricated
according to the present invention. As shown in FIG.
5, the semiconductor device 51 is a multi-chip module
in which for example five semiconductor chips 31 are
flip-chip-connected with the substrate 37 by the stud-
20 bumps 34, and are fixed to the substrate 37 with the
thermosetting insulating adhesive 38.

2 In this fabrication method of the
semiconductor device, a tentative-fixing process for
alignment and a pressing-and-heating process are
25 individually performed. Therefore, individual
apparatuses for the respective processes may be
prepared such as the cure/alignment-and-pressing device
25 for precise alignment and the pressing-and-heating
device 28 for pressing and heating. Thus, an expensive
30 apparatus which has both an alignment mechanism and a
heating mechanism is unnecessary. The above advantages
enable a fabrication apparatus cost to be reduced.

Further, in the cure/alignment-and-pressing
device 25, the heating for thermosetting the insulating
35 adhesive 38 is not carried out, but the semiconductor
chip 31 is aligned and mounted on the substrate 37.
Therefore, it is easy to operate this fabrication

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1 apparatus for mounting many chips. This leads to a reduction of a fabrication cost.

And a plurality of the pressing-and-heating heads 42a may be implemented in the pressing-and-heating device 28, so that a mounting operation becomes also easier, and this also leads to a reduction of the fabrication cost.

As described above, the present invention has the following features.

10 According to the fabrication method of the semiconductor chip, first, the semiconductor chip, on which the projection electrodes are formed, is aligned to the substrate, and is fixed in the first fixing by the pressing ^{a2}only. After that, pressing and heating for thermosetting the insulating adhesive are performed. In such ^away, the first fixing for the precise alignment is performed in a different process from the pressing and heating.

20 In such a process, a less expensive apparatus may be individually applied for an alignment mechanism and a heating mechanism, so that the cost of the fabrication apparatus may be reduced. And at the final pressing and heating, the alignment is already finished, ~~therefore, several processes, such as pressing, heating, and aligning,~~ ^{a3} may be performed ⁱⁿ by a the single process. Thus, the throughput is improved, and as a result, the fabrication cost may be also reduced.

30 And according to the fabrication method of the semiconductor chip, the first pressure is lower than the second pressure. Therefore, when the semiconductor chip with the projection electrodes is fixed in the ^{second}first fixing with the ^{second}first pressure, ~~the dispersion of the degree of collapse of the projection electrodes may be absorbed.~~ ^{deformed uniformly}

Further according to the fabrication method of the semiconductor chip, the second fixing of the

1 semiconductor chips is performed for each semiconductor
chip with the second pressure. Therefore, multi-heads
for pressing and heating become available, which leads
to the improved mounting operation.

5 Further, the present invention is not limited
to these embodiments, but various variations and
modifications may be made without departing from the
scope of the present invention.

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